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Information money fields of cyclic oscillations in nonlinear dynamic economic system

Dimitri O. Ledenyov and Viktor O. Ledenyov

Abstract – Article introduces the notion of information money fields of the cyclic oscillations of the economic variables in the nonlinear dynamic economic system for the first time, and presents an original research on the Ledenyov theory on the information money fields of the cyclic oscillations of the economic variables in the nonlinear dynamic economic system. The Ledenyov theory on the information money fields of the cyclic oscillations of economic variables in the nonlinear dynamic economic system postulates that the economic continuous waves (the cyclic oscillations) have the information money fields in the nonlinear dynamic economic system, transmitting the economic/financial information in the nonlinear dynamic economic system. It is shown that the information money fields may interact with other cyclic oscillations and/or with the nonlinear dynamic economic system by means of the weak and strong interactions between the information money fields. We developed the MicroIMF software program to make the computer modeling of 1) the interactions between the information money fields of one cyclic oscillation and the information money fields of other cyclic oscillation(s) in the nonlinear dynamic economic system, 2) the interactions between the information money fields of cyclic oscillation and the nonlinear dynamic economic system itself, and 3) the density distributions of the information money fields by different cyclic oscillations (the economic continuous waves) in the nonlinear dynamic economic system. The MicroIMF software program can be used in the process of business cycles forecasting by the central banks with the purpose to make the strategic decisions on the monetary policies, financial stability policies, and by other financial institutions with the aim to perform the financial operations on the minimum capital allocation, countercyclical capital buffer creation, and capital investments.

JEL: E32, E43, E44, E53, E58, E61, G18, G21, G28

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Keywords: information money field of cyclic oscillation, generation of cyclic oscillations, amplitude of cyclic oscillation, frequency of cyclic oscillation, wavelength of cyclic oscillation, period of cyclic oscillation, phase of cyclic oscillation, mixing of cyclic oscillations, harmonics of cyclic oscillation, nonlinearities of cyclic oscillation, *Juglar* fixed investment cycle, *Kitchin* inventory cycle, *Kondratieff* long wave cycle, *Kuznets* infrastructural investment cycle, econophysics, econometrics, nonlinear dynamic economic system, macroeconomics.

Introduction

The *evolutionary progress in the economic science* in view of the *disruptive innovation* influence results in the creation of the *empirical theories, models, and schemes in the economics*, aiming both:

- 1) to understand the *nature of economic processes*, and
- 2) to characterize the *fundamental/applied properties of the economic processes*,

as discussed in the *academic literature* in Joseph Penso de la Vega (1668, 1996), Mortimer (1765), Bagehot (1873, 1897), von Böhm-Bawerk (1884, 1889, 1921), Hirsch (1896), Bachelier (1900), Schumpeter (1906, 1911, 1933, 1939, 1961, 1939, 1947), Slutsky (1910, 1915 1923), von Mises (1912), Hayek (1945), Ellis, Metzler (1949), Friedman (1953), Baumol (1957), Debreu (1959), Dodd (2014).

The *modern economics science* is presently divided on the *three main subjects*, which are intensively researched:

- 1) *Macroeconomics*, which considers the *macro-processes in the economics*;
- 2) *Microeconomics*, which deals with the *micro-processes in the economics*;
- 3) *Nanoeconomics*, which is focused on the *nano-processes in the economics*.

In the *macroeconomics*, the *cyclic oscillations of economic variables with the different amplitudes, frequencies and phases* have been discovered as explained in Ledenyov D O, Ledenyov V O (2013c):

“Juglar (1862) discovered the **7 – 11 years Juglar fixed investment cycle**, which is still in the scope of research interest by many scientists in Schumpeter (1939), Grinin, Korotayev, Malkov (2010), Korotayev, Tsirel (2010), Ledenyov V O, Ledenyov D O (2012), Ledenyov D O, Ledenyov V O (2013). It makes sense to explain that Schumpeter (1939) showed that there are the four stages in the Juglar cycle: 1) expansion; 2) crisis; 3) recession; 4) recovery.

Kitchin (1923) proposed that there is the **3 – 7 years Kitchin inventory cycle**. This proposition was investigated in Schumpeter (1939), Korotayev, Tsirel (2010), Ledenyov V O, Ledenyov D O (2012), Ledenyov D O, Ledenyov V O (2013).

Kondratieff (1922, 1925, 1926, 1928, 1935, 1984, 2002) made a significant contribution to the science of economics. The Kondratieff's early research was focused on the big cycles of conjuncture in the World economy in Kondratieff (1922, 1925, 1926, 1928). The discovery of the **45 – 60 years Kondratieff long wave cycle** in Kondratieff, Stolper (1935) had a considerable impact on the science of economics. The Kondratieff's research achievements are comprehensively analyzed in Kondratieff (1984, 2002). Since that time, the Kondratieff long

wave cycle has been a subject of intensive research by many scientists in *Schumpeter (1939)*, *Garvy (1943)*, *Silberling (1943)*, *Rostow (1975)*, *Kuczynski (1978, 1982)*, *Forrester (1978, 1981, 1985)*, *Barr (1979)*, *Van Duijn (1979, 1981, 1983)*, *Eklund (1980)*, *Mandel (1980)*, *Van der Zwan (1980)*, *Tinbergen (1981)*, *Van Ewijk (1982)*, *Cleary, Hobbs (1983)*, *Glismann, Rodemer, Wolter (1983)*, *Wallerstein (1984)*, *Bieshaar, Kleinknecht (1984)*, *Zarnowitz (1985)*, *Summers (1986)*, *Freeman (1987)*, *Goldstein (1988)*, *Solomou (1989)*, *Berry (1991)*, *Tylecote (1992)*, *Metz (1992, 1998, 2006)*, *Cooley (1995)*, *Freeman, Louçã (2001)*, *Modelski (2001, 2006)*, *Perez (2002)*, *Rennstich (2002)*, *Rumyantseva (2003)*, *Diebolt, Doliger (2006)*, *Linstone (2006)*, *Thompson (2007)*, *Papenhausen (2008)*, *Taniguchi, Bando, Nakayama (2008)*, *Korotayev, Tsirel (2010)*, *Ikeda, Aoyama, Fujiwara, Iyetomi, Ogimoto, Souma, Yoshikawa (2012)*, *Ledenyov V O, Ledenyov D O (2012)*, *Ledenyov D O, Ledenyov V O (2013)*.

Kuznets (1973) introduced the **15 – 25 years Kuznets infrastructural investment cycle** in *Kuznets (1973)*, based on his research on the cyclical fluctuations of the production and prices in *Kuznets (1930)*. The researches on the nature of the *Kuznets cycles* were conducted by *Abramovitz (1961)*, *Rostow (1975)*, *Solomou (1989)*; *Diebolt, Doliger (2006, 2008)*, *Korotayev, Tsirel (2010)*, *Ledenyov V O, Ledenyov D O (2012)*, *Ledenyov D O, Ledenyov V O (2013)*. Most recently, *Korotayev, Tsirel (2010)* conducted the spectral analysis and proposed that there is a tight connection between the *Kondratieff long wave cycle* and the *Kuznets infrastructural investment cycle*, suggesting that the *Kuznets swings* represent a third frequency harmonic of the main frequency oscillation, which is generated by the *Kondratieff long wave cycle*, hence the *Kuznets cycle* is not an independent oscillation in *Korotayev, Tsirel (2010)*.”

The **multiple origins of business cycles** (*cyclic oscillations*) have been found as listed in *Ledenyov D O, Ledenyov V O (2013c)*:

- 1) **fluctuations in the aggregate demand** in agreement with the *Keynes* theory;
- 2) **fluctuations in the credit** in accordance with the *Minsky* theory;
- 3) **fluctuations in the technological innovations** as explained in the real business cycle theory;
- 4) **fluctuations in the land price** in agreement with the *George* theory in *George (1881, 2009)*;
- 5) **fluctuations in the politics**.

The **different sophisticated scientific techniques** to make:

- 1) **detection**,
- 2) **filtering**, and
- 3) **measurements**

of cyclic oscillations in the macroeconomics, have been proposed by the scientists, resulting in a discovery of the following cyclic oscillations as noted in Ledenyov D O, Ledenyov V O (2013c):

- 1) 3 – 7 years **Kitchin inventory cycle** in Kitchin (1923);
- 2) 7 – 11 years **Juglar fixed investment cycle** in Juglar (1862);
- 3) 15 – 25 years **Kuznets infrastructural investment cycle** in Kuznets (1973);
- 4) 45 – 60 years **Kondratieff long wave cycle** in Kondratieff, Stolper (1935); and
- 5) 70+ **Grand super-cycle**.

Ledenyov D O, Ledenyov V O (2013c) made an interesting *theoretical proposition* that an interaction between the **business cycles** with the corresponding amplitude, frequency and phase and the **nonlinear dynamic financial and economic systems** can be classified into the two possible types of interactions:

- 1) **Linear interaction**,
- 2) **Non-linear interaction**,

Ledenyov D O, Ledenyov V O (2013c) made an additional crucial *theoretical proposition* that the following four nonlinear effects may originate as a result of the **nonlinear interaction** between the business cycles and the nonlinear dynamic financial and economic system:

- 1) **Four Waves Mixing (FWM) effect**,
- 2) **Stimulated Brillouin Scattering (SBS) effect**,
- 3) **Stimulated Raman Scattering (SRS) effect**,
- 4) **Carrier-Induced Phase Modulation effect**.

The scientific problem on the precise characterization of cyclic oscillations in the macroeconomics has been further researched and comprehensively discussed (in a chronological order) in George (1881, 2009), Schumpeter (1939), Burns, Mitchell (1946), Dupriez (1947), Samuelson (1947), Hicks (1950), Inada, Uzawa (1972), Bernanke (1979), Marchetti (1980), Kleinknecht (1981), Dickson (1983), Hodrick, Prescott (1997), Baxter, King (1999), Kim, Nelson (1999), McConnell, Pérez-Quirós (2000), Devezas, Corredine (2001, 2002), Devezas (editor) (2006), Arnord (2002), Stock, Watson (2002), Helfat, Peteraf (2003), Sussmuth (2003), Hirooka (2006), Kleinknecht, Van der Panne (2006), Jourdon (2008), Taniguchi, Bando, Nakayama (2008), Drehmann, Borio, Tsatsaronis (2011), Iyetomi, Nakayama, Yoshikawa, Aoyama, Fujiwara, Ikeda, Souma (2011), Ikeda, Aoyama, Fujiwara, Iyetomi, Ogimoto, Souma, Yoshikawa (2012), Swiss National Bank (2012, 2013), Uechi, Akutsu (2012), Central Banking Newsdesk (2013), Ledenyov D O, Ledenyov V O (2013c), Union Bank of Switzerland (2013), Wikipedia (2015).

Generation of information money fields by cyclic oscillations in nonlinear dynamic economic system

Let us express our opinion that, in the *academic literature*, the considerable attention is paid to the ***cyclic oscillations of economic variables***, which are normally characterized by the different *amplitudes, frequencies and phases*, for example: ***Juglar periodic oscillation*** in Juglar (1862), ***Kitchin periodic oscillation*** in Kitchin (1923), ***Kondratieff periodic oscillation*** in Kondratieff (1922, 1925, 1926, 1928, 1935, 1984, 2002), ***Kuznets periodic oscillation*** in Kuznets (1973). The ideas on the possible characterization of the *cyclic oscillations of economic variables* have been explored and summarized in Schumpeter (1939), Burns, Mitchell (1946), Hicks (1950), Bernanke (1979), Sussmuth (2003), Devezas (editor) (2006).

Let us note that there are the *two possible scientific approaches* in the commonly accepted research considerations on the *cyclic oscillations of economic variables* in the *academic literature*:

1) in terms of the ***frequency of the cyclic oscillations of economic variables***, hence this terminology is close to the *microwave engineering* and *microwave physics*;

2) in terms of the ***wavelength of the cyclic oscillations of economic variables***, hence this terminology is close to the *optical engineering* and *optical physics*.

The amplitude, frequency and phase parameters are normally used to characterize the cyclic oscillations of economic variables in the space-time domain in agreement with the theoretical representations in the *physics*.

The *authors* would like to highlight an *interesting observation* that the ***notion of the field*** is not used in application to the *cyclic oscillations of economic variables in the time-space domains* in the *economics*. It is necessary to explain that the ***notion of the abstract mathematical field*** has been introduced by the *Euclid* in the *mathematics* for the first time in Ledenyov D O, Ledenyov V O (2015a). For example, in the *mathematics*, it is a well known fact that we can scientifically treat the ***field as the geometrical characteristics of the abstract mathematical space-time domains*** in Ledenyov D O, Ledenyov V O (2015a). Using the knowledge base on the *nature and physical properties of the electromagnetic field, gravitation field, calibrating field, information field* in the *physics*, we would like to assume that the ***cyclic oscillations in the nonlinear dynamic economic system, including the Juglar fixed investment cycle, Kitchin inventory cycle, Kondratieff long wave cycle, Kuznets infrastructural investment cycle, may have the information money fields*** in an analogy with the *electromagnetic periodic oscillations*, which can be characterized by the *electric and magnetic fields* in the *theory of electrodynamics*

in the physics in Ledenyov D O, Ledenyov V O (2015a). In our opinion, the *information money fields of the cyclic oscillations of economic variables in the nonlinear dynamic economic system play an important role of the information transmission about the state of the source of the information money field in the nonlinear dynamic economic system.*

The *Ledenyov theory on the information money fields of the cyclic oscillations of economic variables in the nonlinear dynamic economic system* postulates that the economic continuous waves (the cyclic oscillations) have the information money fields in the nonlinear dynamic economic system, which transmit the economic/financial information in the nonlinear dynamic economic system.

The authors think that the mathematical description of the *structure of the information money fields* can be done in parallel with the Maxwell electromagnetism theory and with the application of the Maxwell equations in the electrodynamics in the physics in Maxwell (1890), Ledenyov D O, Ledenyov V O (2015a), and as it is practically realized in the **MicroIMF** software program.

It follows from the *Ledenyov theory on the information money fields of the cyclic oscillations of economic variables in the nonlinear dynamic economic system* that:

- 1) the information money fields of one cyclic oscillation can interact with other information money fields of other cyclic oscillations, and/or
- 2) the information money fields of one cyclic oscillation can interact with the nonlinear dynamic economic system by means of the weak and strong interactions in the information money fields.

Therefore, in our opinion, the *information money fields*, which are associated with the Juglar fixed investment cycle, Kitchin inventory cycle, Kondratieff long wave cycle, Kuznets infrastructural investment cycle can interact with each other and with the medium such as the nonlinear dynamic economic system.

MicroIMF software program to accurately characterize business cycles and create central bank strategy with optimal monetary and financial policies

The authors believe that the *Ledenyov theory on the information money fields of the cyclic oscillations in the nonlinear dynamic economic system* can be used in the process of business cycles forecasting with the application of the complex algorithms and the parallel computing techniques at the supercomputers by:

1) the *central banks* with the purpose to make the decisions on the *monetary policies*, *financial stability policies*, and

2) the *commercial banks* or *financial institutions* with the aim to perform the *financial operations* towards the *minimum capital allocation*, *countercyclical capital buffer creation*, and *capital investments transactions*.

We developed the **MicroIMF** software program to make the computer modeling of:

1) the *interactions between the information money fields of one cyclic oscillation and the information money fields of other cyclic oscillation(s) in the nonlinear dynamic economic system*,

2) the *interactions between the information money fields of cyclic oscillation and the nonlinear dynamic economic system itself*, and

3) the *density distributions of the information money fields by different cyclic oscillations (the economic continuous waves) in the nonlinear dynamic economic system*.

Let us note that the *changes in the business cycle* characteristics, caused by the *nonlinear interaction* between the *business cycle* and the *nonlinear dynamic financial and economic systems*, have to be taken to the consideration during the process of *accurate characterization of the business cycle* by the *central banks*.

Going from the *econophysical analysis* of the *nonlinear dynamical financial and economic systems*, we propose that the *central bank must create the strategy towards the monetary policy and financial policies using the modeling data on the information money fields of the cyclic oscillations in the nonlinear dynamic economic system*.

Presently, the **MicroIMF** software program has been developed with the application of *object oriented programming languages* and scrupulously tested by the *authors*.

Conclusion

The scientific article presents the *Ledenyov theory on the information money fields of the cyclic oscillations of economic variables in the nonlinear dynamic economic system*.

The *Ledenyov theory on the information money fields of the cyclic oscillations of economic variables in the nonlinear dynamic economic system* postulates that the *economic continuous waves (the cyclic oscillations) have the information money fields in the nonlinear dynamic economic system, which transmit the economic/financial information in the nonlinear dynamic economic system*.

In the *research article*, it is shown that:

- 1) the *information money fields* of one cyclic oscillation can interact with *other information money fields* of other cyclic oscillations, and/or
- 2) the *information money fields* of one cyclic oscillation can interact with the *nonlinear dynamic economic system* by means of the weak and strong interactions in the information money fields.

We developed the *MicroIMF software program* to make the computer modeling of:

- 1) the *interactions between the information money fields of one cyclic oscillation and the information money fields of other cyclic oscillation(s) in the nonlinear dynamic economic system*,
- 2) the *interactions between the information money fields of cyclic oscillation and the nonlinear dynamic economic system itself*, and
- 3) the *density distributions of the information money fields by different cyclic oscillations (the economic continuous waves) in the nonlinear dynamic economic system*.

We think that the *Ledenyov theory on the information money fields of cyclic oscillations in the nonlinear dynamic economic system* and the *MicroIMF software program* can be used in the *process of business cycles forecasting* with the application of the *complex algorithms* and *parallel computing techniques* at the *supercomputers* by the *central banks* with the purpose to make the decisions on the *monetary policies*, *financial stability policies* and by other financial institutions with the aim to perform the financial operations on the *minimum capital allocation*, *countercyclical capital buffer creation*, and *capital investments*.

Acknowledgement

Prof. Joseph Alois Schumpeter started to think on the *business cycles and economic development* in the *economics science* at *University of Czernowitz* in the *City of Czernowitz* in the *State of Ukraine* in 1909 – 1911, completing the writing of his well known book on the *business cycles* in *Schumpeter (1939)*. Therefore, the *first author* would like to say that he decided to fly from *James Cook University* in the *City of Townsville* in the *State of Australia* to *University of Czernowitz* in the *City of Czernowitz* in the *State of Ukraine* to pay his respect to *Prof. Joseph Alois Schumpeter's scientific achievements* in *March, 2015*.

The *first and second authors* were graduated from *V. N. Karazin Kharkiv National University* in the *City of Kharkiv* in the *State of Ukraine* in 1993 and 1999, and would like to comment that our *research interest* in the *economic cycles* in the *economics science* is quite natural, because *Prof. Simon Kuznets* conducted his *scientific work* on the *cyclical fluctuations* in

the economic systems in the City of Kharkiv in the State of Ukraine in 1915 - 1922, being influenced by the Prof. Joseph Alois Schumpeter research ideas and coming up with the remarkable research results in Kuznets (1930, 1973).

Finally, let us note that this research uses the knowledge on the *modeling of the electromagnetic field distributions in the microwave resonators*, which is described in *our book on the nonlinearities in the microwave superconductivity in Ledenyov D O, Ledenyov V O (2015a).*

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1) the operation system to control the firm operation by means of the information resources near-real-time processing in the modern firms in the case of the diffusion - type financial economic system with the induced nonlinearities; 2) the software program to accurately characterize the director's performance by means of a) the filtering of the generated/transmitted/received information by the director into the separate virtual channels, depending on the information content, and b) the measurement of the levels of signals in every virtual channel with the generated/transmitted/received information by the director, in the overlapping interconnecting interlocking directors networks in the boards of directors in the firms during the Quality of Service (QoS) measurements process; and 3) the software program to create the winning virtuous business strategies by the interlocking interconnecting directors in the boards of directors in the modern firms in the case of the diffusion - type financial economic system with the induced nonlinearities, using the patented

recursive artificial intelligence algorithm *ECE James Cook University* Townsville Australia, Kharkov Ukraine.

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